ADVERTISEMENT FEATURE

Biomass boost: driving down the cost of glucose

By using agricultural waste and co-producing other bio-based chemicals, JAPAN IS REDUCING THE COST OF GLUCOSE, one of the global bioeconomy's greatest hopes.

Researchers observe biomass as it is converted into multiple products.

Glucose is a useful sugar that is derived from cellulose.

Adjusting many parameters can help extract more value from biomass.

By yielding multiple products at once, non-edible biomass harvested from rice crops could supply low-cost glucose and drive affordable replacements for everyday chemicals and materials, according to a group of Japanese researchers.

Glucose is used to create biofuels, such as bioethanol, and may eventually be used to replace petroleum-derived chemicals, such as ethylene and propylene – which are made into many things including the plastics used in shopping bags and packaging, solvents, cosmetic compounds and pharmaceuticals. But the cost of the biomass used to produce glucose has created a bottleneck in the supply chain, explains Professor Jun-ichiro Hayashi of Kyushu University, who leads a Japanese consortium studying agri-bio chemical systems.

By using not only the cellulose from biomass, but multiple components – including hemicellulose, lignin, silica and isoprenoid – Hayashi's group aims to bring down the cost of glucose by more than 30% to roughly ¥30 (US$0.28) per kilogram.

Co-produced substances that can offset costs include, pulps and silica-lignin molecular composites that can be used to create textiles and paper-like materials, and xylo-oligo sugars, which are used as prebiotics that feed gut flora, says Hayashi. In addition, isoprenoids and polyphenols can be extracted via steam or ethanol distillation and commercialized as sanitizers that combine antibacterial, antiviral, antioxidant, and anti-UV functions.

THE AIM IS TO BRING DOWN THE COST OF GLUCOSE BY MORE THAN 30%

Cellulose dreams

The team is also making glucose more efficiently. For example, by heating both low and high purity pulp to 300–400°C they have produced levoglucosan, a type of anhydrosugar that can also be converted into glucose, shortening the enzyme reaction time from as long as 72 hours down to three minutes. Levoglucosan can also be synthesized into new types of sugar esters and ethers with applications in foods, cosmetics, detergents and medicine, to name a few.

Hayashi and his colleagues also see more than just sugar in cellulose. Using different genetically-modified enzymes, they have co-produced both glucose and a nano-sized cellulose product that could find use in materials for farming, such as mulch films.

An even tinier cellulose nanofibre, currently produced at a higher price, can be created directly from pulp using a new chemical reaction. Hayashi says that reducing the costs of this product, also used in agriculture, will enable a wider application of the material.

The consortium is also developing yeast that can efficiently produce oleic acid from glucose. After use, the yeast residue, which is packed with proteins and nutrients, could also be used as fish feed.

Hayashi calls these offerings that are extracted from one biomass base, agri-bio-based smart chemical production systems (ABCs). The most difficult part, he says, "more than developing new technologies" is to create a unified business model that can bring things like their glucose system into operation by their targeted date of 2023.

One possibility is that the prefectural government of Akita, in northern Japan – home to the popular 'Akitakomachi' rice breed and where the team's initial operation is planned – could establish a holding company with investors from which businesses can license all or part of an ABC, he suggests. "We expect that this will become a core system in the post-petroleum chemical industry."

The bioeconomies of recycling

Hayashi's consortium is linked to a wider team researching resource circulation for a government initiative known as the Technologies for Smart Bio-industry and Agriculture programme. The aim is to create more sustainable bioproduction and circular agriculture models, says Wataru Mizunashi, who works on the SIP project.

Bioproduction is rapidly evolving in Japan, Mizunashi says. He points to a RIKEN and University of Tokyo project that has successfully developed aromatic biopolymers with high heat-resistance using enzymes and microorganisms. Work is in progress to commercialize these materials for use in batteries and automotive parts materials, he says. Another team is tweaking the mechanism of silk worms to produce high-function proteins for healthcare, medicines and diagnostic reagents.

But if bioproduction is to compete with traditional industries, it will need to be clever and highly efficient, he says. Researchers at the National Institute of Advanced Industrial Science and Technology are collaborating on recycling treatment systems for the food sector. Their efforts include cultivating microalgae from food production wastewater, extracting supercritical CO_2 – a low toxic solvent used for chemical extraction – and purifying inorganic membranes. Utilizing data-driven technology, a number of team are also hoping to establish similar sustainable, cost-efficient waste management systems to collect valuable substances that can be recycled back in biochemical production.

While market competitiveness is important, the overarching goal of all this work, Mizunashi says, "is to build circular systems that reduce environmental impact".

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